ORIGINAL PAPER

Economic integration and similarity in trade structures

Luca De Benedictis · Lucia Tajoli

Abstract In this paper, we look at the similarity of the trade structures toward the EU market between four CEECs and the EU15. We evaluate the appropriateness of different indices to compare export flows—correlation indices and distance metrics—opting for the use of the Bray-Curtis semimetric. We examine both how the export composition of a country has changed over time and how the export composition has changed with respect to the EU15 export composition. Finally, we test if the dynamics of sectoral distribution of the CEECs' exports is related to the role acquired by processed trade in the 1990s. We give evidence that processed trade is crucial in explaining changes in the overall structure of exports of transition countries, and that greater economic integration in terms of trade flows and processing trade does not always lead to greater export similarity.

Keywords EU · CEECs · Transition · Similarity · Nonparametrics

JEL Classification F3 · F42

Introduction

The trade effects of economic integration between a group of countries have been studied extensively since the path-breaking analysis of Jacob Viner in

L. De Benedictis (✉)
DIEF, University of Macerata, Via Crescimbeni 20, Macerata 62100, Italy
e-mail: debene@unimc.it

L. Tajoli
Dipartimento di Ingegneria Gestionale, Politecnico di Milano,
Via Giuseppe Colombo 40, Milano 20133, Italy
e-mail: lucia.tajoli@polimi.it

1950 and the signing of the Treaty of Rome in 1957. Much emphasis has been placed on the welfare effects of the change in trade volumes and trade partners related to regional integration agreements, but the issue of how economic integration might change the specialization and the export composition of a country has received less attention. In this paper we address this issue, examining the case of trade integration between the pre-2004 European Union members (EU15) and four Central-Eastern European Countries (CEECs): Poland, Hungary, Romania and Bulgaria. The integration of the CEECs with the EU15 is an extremely relevant experiment of how the elimination of trade barriers might shape a country trade structure. In fact the CEECs, opening their economies to the international markets in the 1990s, to a large extent had to restructure their specialization pattern, following a long period of economic isolation from the rest of the world.

Our research objective is twofold: (1) finding if this restructuring brought the CEECs to become more similar to the EU15 in terms of trade structure; (2) test if the changes in similarity have anything to do with the increased relevance of processing trade in this countries. Finding if countries are becoming more or less similar in trade structure[1] (and what variables are influencing this process) is an important issue, specially in the context of regional integration.[2] We pursue our objectives examining the export flows toward the EU market of four of the so-called ''accession countries'' of Central and Eastern Europe by comparing them to those of the EU15.

Measuring and describing a country's overall export pattern and its changes over time is not an obvious task. From a methodological point of view, we tackle the issue of similarity, evaluating the general and specific appropriateness of different classes of similarity indices—correlation indices and distance metrics—opting for the use of the Bray-Curtis semi-metric to assess changes in the trade similarity. We examine its evolution over time—from 1989 to 2001—considering both self-similarity (how the export composition of a CEEC has changed with respect to the beginning of the transition process) and EU-similarity (if and how the export composition of a CEEC has changed with respect to the EU15 export composition).

---

[1] It is far from obvious whether countries increasing their mutual trade exchanges should become more similar in their export structures. A priori, theoretical models allow both possibilities of increased similarity and dissimilarity. Countries can be pushed by trade toward a polarization of their export structures following their comparative advantage (to the extreme case of full specialization in a few sectors for small countries). But not all trade is driven by comparative advantages, and similar export patterns can be observed for highly integrated countries such as the European ones. If the removal of barriers to trade is accompanied by the removal of obstacles to movement of factors of production, the number of possible outcomes is further increased, as re-localisation and restructuring of industries at the regional level can occur both through domestic resource reallocation and through delocalisation of industries between countries (Forslid et al. 2002).

[2] In the trade literature it is often assumed that similarity in production and trade structures among countries will ease the integration process, allowing to improve resource exploitation while requiring relatively small industry reallocations (see Krugman 1981; Menon and Dixon 1997).

Finally, we use EU-similarity matrices to test if the dynamics of sectoral distribution of total exports of Poland, Hungary, Romania, and Bulgaria to the EU is related to the role acquired by processed trade in the 1990s. Using a nonparametric Mantel test we give evidence that: (1) processed trade is crucial in explaining changes in the overall structure of exports of transition countries, and (2) that greater economic integration in terms of trade flows and processing trade does not always lead to greater export similarity between the CEECs and the EU15 member States. Poland, Hungary, Romania and Bulgaria changed indeed their patterns of sectoral exports towards the EU. The change is remarkable, different for every country, and lasting beyond the early phases of their transition. Such differences appear to be linked to the involvement of these countries in international production networks, through the recourse to processing trade.

Exports, export composition and outward processing trade

Our analysis focuses on the changes that occurred in the exports of Poland, Hungary, Romania and Bulgaria towards EU 15 member States, between 1989 and 2001. We chose these countries because they account for 70% of the total trade of the CEECs with the EU, and here we want to consider exclusively their transition process in terms of changes in trade patterns. Our implicit assumption is that the CEECs' exports embody many of the underlying changes in their economic structures as they occurred through the transition and the economic integration with the EU.[3] Poland and Hungary are both countries normally considered well advanced in the process of transition, they both signed agreements aimed at liberalizing trade with the EU at very early stages of the opening-up process, but they are however remarkably different.[4] Romania and Bulgaria are much behind in their transition path, they have much lower levels of income per capita, and they are expected to join the EU only in 2007. We expect therefore that differences in the starting points and in the transition process would show up in the evolution of trade structures.

In the analysis, we extracted from the *Comext Eurostat Database*—containing custom trade data collected by EU national statistical institutes—the flows in value terms (thousands of euro) of both *total exports* towards the EU15, which include conventional trade flows as well as temporary EU

---

[3] The central role of trade in transition is addresses in many of the early works on the CEECs as well as in more recent assessments of their economies. See for example Halpern (1995), Kaminski et al. (1996), Hoekman and Djankov (1997), Landesmann (2002), Landesmann and Stehrer (2002).

[4] For instance, Poland is much larger than Hungary in terms of population and land, and it has a much larger agricultural sector. In transition, Poland followed the so-called ''shock therapy'' approach, while the Hungarian government chose a much more gradual approach (Facchini and Segnana 2003). For a comprehensive review of the transition process in the CEECs, see Svejnar (2002).

exports of goods to be processed, and *final exports* towards the EU15 at a 2-digit sectoral level of the Combined Nomenclature organized in the 97 sectors listed in Appendix 1. Subtracting final exports from total exports, we obtain the value of temporary exports recorded as Outward Processing Trade (OPT).[5]

Figure 1 summarizes the dynamics of Poland, Romania, Bulgaria, and Hungary total and final exports towards the EU15, taken as an aggregate, while Fig. 2 displays the change in the export structure. A few stylised facts emerge from these figures.

First, even if all countries increased remarkably their exports toward the EU, Fig. 1 shows eloquently that each of the four export pattern is a case on its own.[6] Hungary and Romania show the most remarkable increase, especially in the second half of the 1990s, but the fit of the regression line of total exports on a linear time trend indicates that the linear functional form is probably not the most appropriate choice.

Second, considering separately exports of final goods and re-exports after processing, more differences emerge among countries. Re-export flows in Poland and Hungary were almost irrelevant in 1989 and reached a maximum relevance in 1996, slowly decreasing until 2001.[7] In contrast, the role of processed trade in Romania is and remains substantial during the second half of the 1990s, as shown in Fig. 1. In Bulgaria, final trade alone grew at a slower pace than trade inclusive of processing traffic. The difference in the two trend coefficients for each country is statistically significant in all cases, and it is quite large for Romania and Bulgaria.

Third, for all four countries the large majority of sectors contribute to total exports with a very small share, below 0.5%, very few industries have a share of 10% or higher, so that the distributions of export shares are always right

---

[5] It is important to underline the difference between total and final or normal exports because total flows include goods temporarily exported to be processes and re-imports of processed goods. This kind of trade constitutes a large part of the CEECs' trade in some sectors, but these flows are to a large extent activated and controlled by EU firms rather than by local firms and local production capacities.The *Comext Eurostat Database* records separately normal or final trade flow (mainly goods exported definitely and released into free circulation, either directly or via a customs warehouse) from the trade flow which has undergone outward processing. Outward processing makes it possible to export goods temporarily for processing and to import the compensating products with a full or partial exemption from duties and levies.

[6] The choice of the base year is irrelevant for the shape of the four series in Fig. 1. The choice is therefore only suggestive: 1992 is a significant year in terms of trade reorientation as the former USSR no longer exists.

[7] A part of the decrease observed in the Eurostat database in the flows of processed re-exports in Poland and Hungary can be due to statistical reasons. Brenton and Manchin (2003) convincingly argue that registration of temporary flows continues where it guarantees the costless way of accessing the EU market in presence of stringent regulation of Rules of Origin. Scattered evidence from the CEECs' statistical sources (rather than from Eurostat) shows no negative trend in processing trade even in very recent years. For an analysis with Romanian data see De Arcangelis et al. (2005).
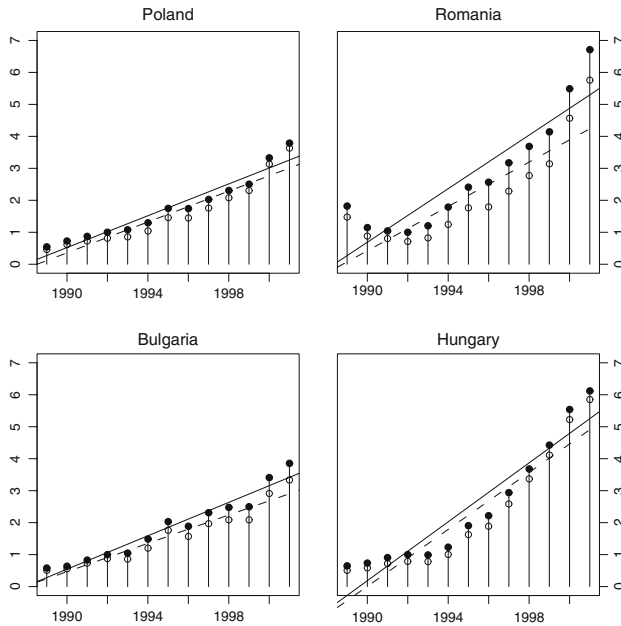
Fig. 1 CEECs Exports towards EU: Total and Final Exports. Note: Total exports are represented by the vertical lines surmounted by darker dots, while the lighter dots correspond to final exports. In all cases the exports flows are measured relative to 1992 value of national exports towards the EU (Total Exports in 1992 = 1). The lines represent an estimate of total (continuous line) and final (dotted line) exports towards EU15 obtained through a simple linear regression of exports on a time trend (See Appendix 2 for details)

skewed.[8] In 1989, only a handful of sectors were comparatively more important for all the countries examined: these are fuels, iron, and apparel. Poland, Hungary, and to some extent Bulgaria displayed a specialization in machinery and electrical machinery as well, and Poland and Romania in the furniture sector. Autovehicles' export in Poland were moderately relevant already back in 1989. All countries exported agricultural products to the EU.

As shown in Fig. 2, visible changes appear in a limited number of sectors (the dots further away from the diagonal) that seem to drive most of the modification in the export structure. It is difficult to describe a common pattern of exports for the CEECs in 2001, even if most of them had moved away from agriculture toward traditional manufacturing industries. Even if the concentration of change in a few industries is a common feature to all these countries, the affected industries and the direction of change are different between countries.

The final observation refers to the fact that a number of the sectors whose share has visibly changed in the observation period are affected by OPT, as

---

[8] The right skewness of the distributions can be deduced from Fig. 2, noticing the scale of both horizontal and vertical axes. The same result is evident from the shape of box-plots (that can be requested from the authors).
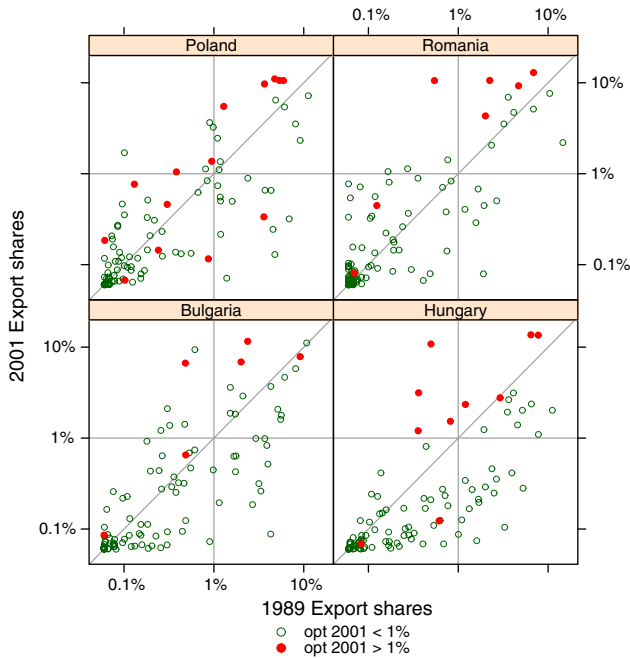
Fig. 2 Changes in export structure and fragmentation of production between 1989 and 2001. Note: Export shares in 97 industries in 1989 (horizontal axis) and in 2001 (vertical axis). Sectoral exports are in percentage indicating for each country the share of each industry on its overall exports toward the EU. Data are plotted on a asymmetric scale around 1%, in order to give more visual emphasis to sectors with a share greater than 1%. Darker (red) bullets identify sectors in which OPT is >1% of total OPT in 2001

indicated in Fig. 2. Table 1 shows that generally the sectors where OPT is concentrated display an increase in their share on total exports between 1989 and 2001, even if the relevance of OPT and its effect on the countries' export shares is quite differentiated. For instance, a relevant part of OPT takes place in the machinery sector for Poland, Hungary and Bulgaria, but while in Hungarian and Polish total exports the share of machinery increased sharply, the same share actually declined for Bulgaria. Apparel and knitted apparel absorb much of the processing trade for all the countries considered, but the effect on the relevance of this sector on total exports is strong for Bulgaria and small for Hungary. Overall, OPT is concentrated in a few sectors within the mechanical and traditional industries, but its presence is associated to significant changes in export shares.

Comparing the export composition of countries

In this section, we will quantify more precisely mobility and persistence in export composition with the help of appropriate indices.

Table 1 OPT shares and export shares growth

	Poland	Hungary	Romania	Bulgaria
Fish	2.07 [–506%]			
Meat preparations	4.23 [–582%]			
Cotton		1.71 [–382%]		
Textile fibres	1.00 [–391%]			
Leather goods				1.22 [19%]
Knitted apparel	9.69 [23%]	10.24 [36%]	9.71 [60%]	37.80 [69%]
Apparel	40.23 [70%]	16.60 [38%]	56.19 [74%]	44.65 [86%]
Other textiles	3.85 [52%]			
Footwear		6.63 [59%]	18.52 [94%]	4.69 [88%]
Aluminium			1.04 [47%]	
Cutlery and tools	3.18 [–78%]			
Machinery	6.06 [72%]	17.19 [74%]		1.16 [–28%]
Electrical machin.	8.90 [65%]	31.04 [81%]	3.98 [47%]	
Railway	1.36 [80%]			
Autovehicles	2.85 [60%]	1.23 [95%]		
Aircraft	1.19 [98%]	1.88 [–133%]	2.09 [51%]	5.51 [100%]
Precision tools	1.42 [28%]	2.53 [80%]		
Furniture	4.16 [71%]	1.69 [–4%]		
Toys			2.34 [73%]	

Note: The table shows sectors with OPT share >1% in 2001 and reports the share of each of these sectors on OPT export (in percentage). Numbers in square brackets are the growth rate of total export in the same sector between 1989 and 2001

The traditional measure of the degree of association between two variables is Pearson's coefficient of correlation, which captures the strength of the *linear* association between the two variables taking the mean as the positional index and the standard deviation, σ, as the spread of the two distributions. In the present case, at any given point in time $t \in [1989, 2001]$, the two variables are vectors of sectoral export's shares $x \equiv [x_1, \ldots, x_n]$ and $y \equiv [y_1, \ldots, y_n]$, with $0 \le x_i \le 1$ and $0 \le y_i \le 1$, so that the coefficient of correlation is

$$r_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y} = \frac{\sum_i (x_i - \frac{\sum_i x_i}{n})(y_i - \frac{\sum_i y_i}{n})}{\sigma_x \sigma_y}. \tag{1}$$

The distribution of CEECs exports to the EU is markedly skewed (even after the log transformation of the data). In presence of pronounced asymmetry the mean overestimates the location of the distribution and the standard deviation gives a distorted account of the spread of the distribution. Under these circumstances, there is a strong presumption that the coefficient of correlation could not be the most appropriate index to use in measuring the similarity of CEECs sectoral exports structure along time or with respect to that of the EU, and that a more robust method should be used. The confirmation of such a presumption is an empirical matter, the level of distortion being related to the degree of asymmetry in the distribution.

In order to bypass the problem posed by the comparison of asymmetric distributions, the traditional choice is to use a correlation coefficient based on

ranks.[9] However the use of rank correlation induce a trade-off. It under emphasizes by construction the role of the mean, which is precisely fine given the skewness of the data, but at the cost of giving no relevance at all to sectors relative weights, which is in our case an excessive information loss.

A different and preferable alternative is to measure similarity in terms of distance[10] selecting the best candidate among the many distance metrics used in geostatistics and in biostatistics (Legendre and Legendre 1998).[11]

Among the many candidates for which the above properties are respected, the most common metric measure is the *Euclidean distance*.[12]

The use of the Euclidean distance as a measure of EU-similarity or as a measure of self-similarity on the basis of sectoral relative weight, may lead to a well reported phenomenon (Legendre and Legendre 1998) called the *double-zeros paradox* of two countries without any sectoral share in common that because of a number of zero observations in the sample appear as being at a smaller distance than another pair of countries characterized by the same structure of sectoral export shares. In general, double-zeros lead to reduction in distances. In our case the number of sectoral shares with zero value is

---

[9] We calculated the Spearman's rank correlation coefficient, ρ_{xy}, between each country in our sample and the EU along time and we also use ρ to calculate autocorrelation matrices for each country, measuring the rank correlation between sectoral export's shares of the same country given a time lag. In this case the $t \times t$ autocorrelation matrix contains the t^2 couples of rank correlations (but only $t \times (t-1)/2$ pieces of information) between two specific years. All correlation and autocorrelation matrices are available on request.

[10] It is worthwhile noticing that since distance (dissimilarity) is equivalent to the additive inverse of similarity ($d = 1 - s$) when $d \in [0,1]$, using similarity (or closeness) instead of dissimilarity has no qualitative effect on the analysis: it merely changes the sign of the coefficients. We will make use of this property in Sect. 4.

[11] All metrics used as a measure of distance must share the same properties, so that we can say that an index d is a metric if:

1. $x = y$, then $d_{xy} = 0$

2. $x \neq y$, then $d_{xy} > 0$

3. $d_{xy} = d_{yx}$

4. $d_{xk} + d_{ky} \geq d_{xy}$

where property (1) states that the minimum distance should be 0; property (2) says that distance should be a positive real number; property (3) assumes that symmetry is respected; and property (4) states triangular inequality (not respected in cases of semi-metrics). As a remark, the Pearson's correlation coefficient is a semi-metric, respecting properties 1–3 and violating property 4.

[12] The Euclidean distance between two countries x and y identified by n sectoral export shares is computed applying Phythagora's formula to country-points in a n-dimensional space. The Euclidean distance is bounded to the left but it does not have an upper limit, its value increasing in n, and it depends on the scale of x and y, changing the scale may result in measures that are not monotonic to each other (Legendre and Legendre 1998). To avoid this inconvenience, variables should be standardized or should be dimensionally homogeneous.

limited but not irrelevant, therefore, we chose to use the *Bray-Curtis* formula,[13] obtained by normalizing the Manhattan distance:[14]

$$d_{xy}^{bc} = \frac{\sum_i |x_i - y_i|}{\sum_i (x_i + y_i)}.$$ (2)

The Bray-Curtis semi-metric is a bounded measure, $0 \le d_{xy}^{bc} \le 1$, it has the advantage of not increasing in n, of being invariant to proportional sub-classifications of the n sectors considered,[15] it is not subject to the *double-zeros paradox*, it lessens the effect of the largest differences since difference in high sectoral export shares contribute the same as difference between small sectoral export shares, and is appropriate in presence of skewed distributions. The d_{xy}^{bc} semi-metric has also the suggestive characteristic of being equivalent to the Finger and Kreinin (1979) Index,[16] when x_i and y_i are shares, as they are in our case.

Similarity and convergence in trade structures

To facilitate the interpretation of the data, we use a similarity index defined as $s_{xy}^{bc} = 1 - d_{xy}^{bc}$. We will calculate *self-similarity* in order to measure the distance of each one of the members-to-be to the beginning of the transition process. Moreover, we will calculate *EU-similarity* measuring the distance between each member-to-be export structure and that of the EU15 as a whole. The EU export structure considered here is given by exports of EU15 members toward the EU market only, so that EU15 and CEECs exports are compared on the same market.

The EU is an appropriate benchmark not only because of the ongoing integration process and the absolute relevance of the EU market for the CEECs exports (over 60% of the CEECs exports is directed to this market), but also because, since the EU export composition has been very stable during our observation period, convergence or divergence in trade structures is due to changes occurring in the CEECs export composition. Computing and

---

[13] The Bray-Curtis semi-metric—largely used in the natural sciences—takes its name from the two botanists that in 1957 used it in the analysis of forest species in southern Wisconsin. The index has been attributed to the zoologist Odum by Legendre and Legendre (1998) and has been derived by Sun and Ng (2000) taking an axiomatic approach.

[14] In spite of its use in trade empirics (Krugman 1991; Clark and van Wincoop 2000; Imbs 2001), the Manhattan metric presents, however, the same problems of right unboundedness and of double zeros as the Euclidean distance does.

[15] The index is invariant to *proportional* sub-classification, not to sub-classification *tout court*. If one moves from 2-digit level to 4-digit level of the Combined Nomenclature some sector will become heavily disaggregated while others will remain virtually untouched. In this case the index could vary its numerical value but still remains less sensitive than other possible alternatives to the level of aggregation of the data considered.

[16] The Finger-Kreinin index, $d_{xy}^{fk} = \sum_i \min(x_i, y_i)$ is the only case of distance (semi)metric that has been explicitly selected for the measurement of export similarity.

plotting the correlation coefficient r_{xy} and the similarity index s_{xy}^{bc} the changes in the CEECs export structure relative to their initial situation and to the EU are more readily evident. For both indices, a value of 1 represents identity with the initial situation or with the EU, respectively, and a lower value indicates the extent of the difference. The use of these indices confirms that many important changes occurred in the pattern of sectoral export shares of the CEECs toward the EU market in the past decade. It is worth noticing that a large number of changes took place toward the end of the 1990s, much after the initial phase of transition.

Self-similarity: moving away from 1989s exports structure?

The observation of Fig. 3 suggests that the CEECs export structures indeed display a strong dynamics: in the past decade CEECs' exports changed much more extensively than the EU export and remarkable differences appear in the path followed by the four countries examined. In Poland, the fall of r_{xy} after 1995 shows that export shares kept moving also in the most recent years. In terms of this index, the Polish trade structure of 2001 is less similar to the one of 1995 than the latter was to the one of 1990. The similarity indices present a similar pattern, indicating that Poland kept moving away from its initial specialization, and there is a remarkable distance also between the current trade pattern and the one of 1995.

The change in the Hungarian pattern of trade is even sharper: by comparison with the dynamics of the EU trade pattern, one can appreciate the
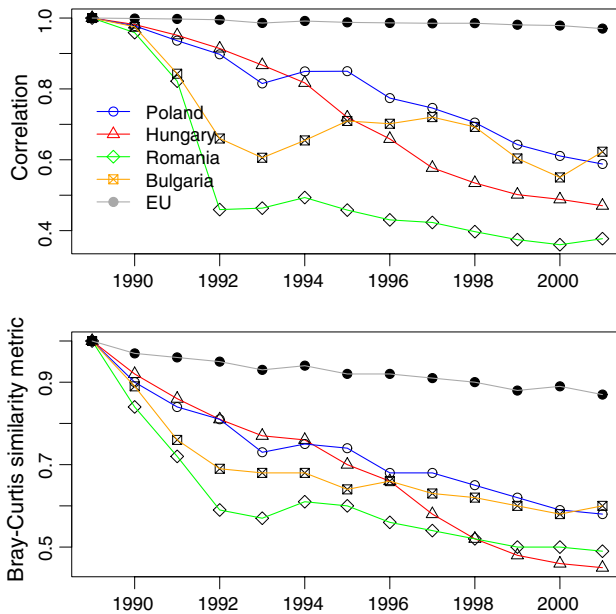
Fig. 3 Self-similarity dynamics

extent of the changes that affected the Hungarian export shares. While the self-correlation for the EU is never lower than 0.96, and the value of the similarity metrics is never lower than 0.87, for Hungary the Pearson's correlation between exports in the year 1989 and 2001 is only about 0.5 and the similarity measures arrive to 0.45, much lower than in the Polish case.

The dynamics is quite different in the case of Romania and Bulgaria. Over the entire time span, Romania changes more than Hungary and Poland in terms of correlation, but most of the change is concentrated in the early years and takes place before 1992. After this initial big jump, Romanian export shares show a modest dynamic. The country appears locked in the specialization reached in the early 1990s. Something similar occurs to Bulgaria, which has changed especially at the beginning of transition and shows a period of stability in the mid-1990s, while some movement starts to appear again in the last few years. Note that the extent of change for Romania seems stronger than for Hungary using r_{xy}, but not when the similarity index s_{xy}^{bc} is used.

Summing up, at the beginning of the 2000s, the overall picture of the CEECs specialization looks remarkably different from just 5 years earlier, and it seems difficult to relate these changes to the initial transition shock only. These changes are far from being uniform across countries. As the transition process went on, substantial diversity emerged among the CEECs, who display different dynamics of overall changes, and different sectoral movements.[17]

Possibly, given that much of the change is concentrated in a few industries, the dynamics of specialization depends on which are the sectors driving the change.[18] While Romanian and Bulgarian exports are concentrated first of all in traditional, labour-intensive industries (such as textiles, apparel and footwear), Poland's and Hungary's exports grew in industries such as autovehicles and machinery, in spite of the very large initial gap with the EU members in these sectors. In this catching-up process, it is likely that foreign capital and technological cooperation with EU firms played an important role.

EU-similarity: converging toward the EU trade structure?

In this section, we examine whether the observed change in the CEECs export structures brought these countries closer to the EU structure. Here again we use r_{xy} and s_{xy}^{bc}, comparing them in Fig. 4.

In the case of Romania the indices are concordant in giving evidence of a fluctuating path until 1995, while only after 1997 the country shows some convergence toward the EU export structure. The tendency for Bulgaria is even more unexpected. This country's export structure has been diverging from the one of the EU, and this tendency appears quite clearly from all

---

[17] The tendency toward diverging specializations among the CEECs is pointed out also in other studies (Chiarlone 2002; Landesmann and Stehrer 2002).

[18] Our evidence is in line with Redding (2002) that suggests that over medium time horizons (5 years), changes that are specific to individual industries explain most of the observed mobility in the patterns of specialization of the OECD countries he examines.
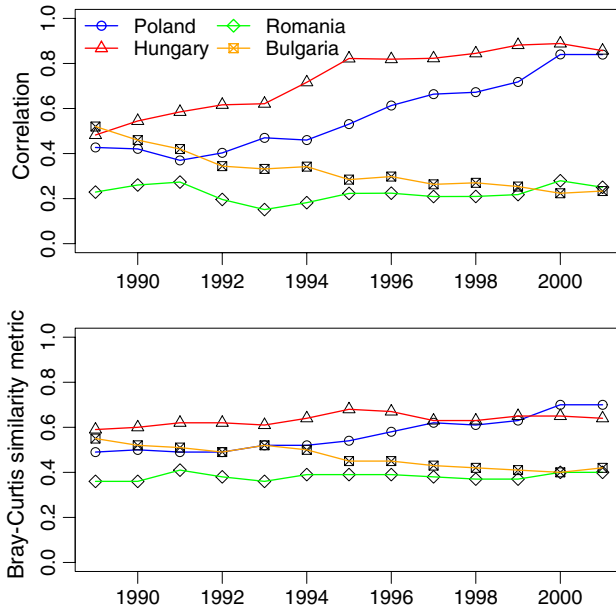
Fig. 4 EU-similarity dynamics

indices. Even in the last period, there are no signs of a reversal in this trend. In the case of Poland, all indices show convergence toward the EU, especially after 1994, and possibly speeding up in the last few years.

Finally, the Hungarian case is paradigmatic and gives the possibility of solving the methodological issue regarding the choice of the appropriate metric to use in the analysis of similarity. Contrary to the other three cases, in the one of Hungary the correlation index and the Bray-Curtis metric are *not* monotonically related. In terms of correlation, Hungary approaches the EU and gets even closer than Poland. But if we look at the similarity indices, after a period of fast reduction in the distance from the EU, from 1995 onward Hungary reversed is trajectory and start diverging from the benchmark.

Why this inconsistency among metrics? Which index should we trust? Leaving the more proper analytical treatment of both questions to the Appendix, the careful examination of the data is sufficient to give hints to what drives both answers. Broadly speaking, one can say that the explanation is in the dynamic of Hungarian sectoral export shares "overshoot" EU sectoral export shares. In fact, on the one hand, sectors relevant in 1989—such as Meat and Apparel—decrease their relevance along time, on the other hand, sectors as automobiles, machinery and electrical machinery become more and more relevant. Both changes contribute to the increase in the Hungarian EU-similarity, regardless of the metric used. After 1995, the share of the fast growing sectors, increasing but till then smaller than for the EU, becomes progressively higher than that for the EU. This leaves unchanged the trajectory of the correlation index, while inverting the one of the Bray-Curtis semi-metric. After

1995 only s_{xy}^{bc} is catching the peculiarity of the Hungarian path, and in this respect s_{xy}^{bc} is a superior metric because the use of r_{xy} hides the evidence of an ''overshooting'' paths.

A summary of the information content of Fig. 3 and 4 on the dynamics of the CEECs' self-similarity and on the eventual convergence toward the EU export structure is presented in Fig. 5, measuring on the horizontal axis the yearly EU-similarity of each country's export structure, and on the vertical axis each country self-similarity. Vertical movements show the extent of the changes in a country export structure, and rightward horizontal movements indicate convergence toward the EU.

Figure 5 once more shows that the evolution of the candidates is remarkable and quite differentiated. The country that changed the most its initial trade structure appears to be Hungary, followed by Romania, and Bulgaria. Poland has undergone fewer changes from the initial structure than the other countries. Interestingly, Poland is considered to be the country that was fastest during the 1990s in stabilizing its macroeconomic fundamentals, but most observers agree on the fact that in microeconomic terms Poland still has a long way to go. Anyway, in the year 2001, Poland seems to have the most similar structure to the EU. Hungary is instead characterized by a reversal in its EU-similarity due to an ''overshooting'' path after 1995, driven by the increasing role of the Machinery and Electrical Machinery sectors.

Integration, processed trade, and similarity in export composition

Our next step is to test if the dynamics of sectoral distribution of total exports of Poland, Hungary, Romania, and Bulgaria to the EU is related to the role
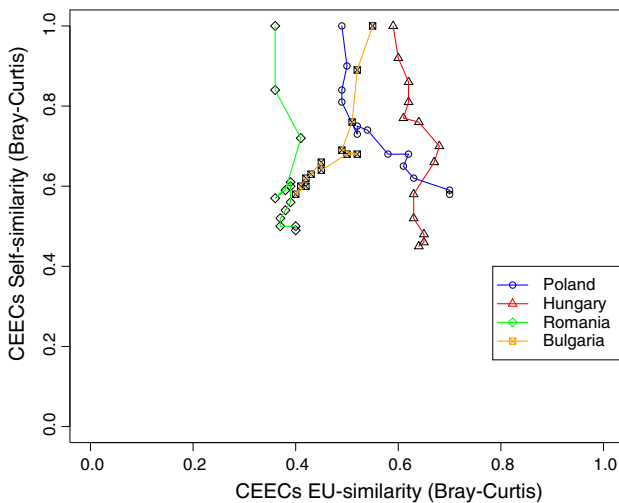
Fig. 5 Self and EU similarities

Table 2 Mantel's test results

	Bray-Curtis	
	Spearman's correlation	Pearson's correlation
Poland	0.908 (0.383)	0.897 (0.375)
Hungary	0.937 (0.382)	0.940 (0.383)
Romania	0.930 (0.542)	0.940 (0.581)
Bulgaria	0.856 (0.502)	0.882 (0.470)

Note: Empirical 99% upper confidence limits of the Mantel's statistic m in parenthesis. If the value of the correlation is larger than m the null hypothesis of absence of a statistical match is not accepted

acquired by processed trade in the 1990s. But this task is confounded by two fundamental issues. First, total trade and processed trade are intercorrelated among themselves,[19] and so it may be difficult to ascribe causal mechanism even if it can be shown that the convergence/divergence with respect to the European benchmark is correlated with countries' sectoral export distribution. Second, trade variables are highly persistent, and so their influence is likely to be expressed only at particular scales of reference. Furthermore, the likelihood that the sectors itself may exhibit high autocorrelation in its distribution is not a extreme event, due vertical and horizontal linkages.

In conventional statistical analyses, the former problem is addressed via multivariate methods that allow one to attend the correlations among predictor variables; partial regression is a familiar solution to this problem. But conventional parametric approaches are confounded by the second issue, namely that autocorrelation in the variables violates the assumptions of parametric analysis.

Mantel's test

Mantel's test (Legendre and Legendre 1998) is an nonparametric approach that overcomes some of the problems inherent in explaining the relationships between total exports (τ) and processed trade (π). Mantel's test is a regression in which the variables are themselves distance or dissimilarity matrices summarizing pairwise similarities among time periods.

One advantage of Mantel's test is that, because it proceeds from a distance or a similarity matrix, it can be applied to different kinds of variables (categorical, rank, or interval-scale data) and all that matters is that an appropriate distance metric be employed, such as one we used previously. The Mantel statistic m can be described as the evaluation of the significance of a matrix correlation between two dissimilarity matrices. Since the significance cannot be directly assessed, because there are $N(N–1)/2$ entries for just N observations, the test uses permutations of N rows and columns of *one* dissimilarity

---

[19] See footnote 3.

matrix. The statistic can be evaluated either as a moment correlation (see first column in Table 2) or as a rank correlation (see second column in Table 2).

Because the elements of a distance matrix are not independent, Mantel's test of significance is evaluated via permutation procedures. In this, the rows and columns of one of the two distance matrices are randomly rearranged. Mantel statistics $m = \sum_i^T \sum_i^T d_{i\tau} d_{j\pi}$ are recomputed for these permuted matrices, and the distribution of values for the statistic is generated via an iterative procedure.[20]

Results

We applied a Mantel's test to each one of the four countries considered in the analysis, using distance matrices for total exports shares τ and for processed export shares π. The operative question is, "Do changes in self-similarity in processed trade tend to match changes in total export self-similarity?"

We applied the Mantel's test to the Bray-Curtis distance matrices using either as a Pearson's correlation or as a Spearman's rank correlation, iterating the procedure of column-row permutation 1,000 times.

In all cases, with notable differences, the operative question passed the nonparametric test, meaning that changes in total exports occurred along with the changes in processed trade. This suggests that processed trade is crucial in explaining changes in the overall structure of exports of transition countries. This is true not only for Poland and Hungary, whose trade structures are getting more similar to the EU, but also in the case of Romania (no convergence toward the EU export structure) and even in the case of Bulgaria (divergence from the EU export structure). Apparently, the phenomenon of delocalisation of production witnessed by the extent of processed trade, can enhance complementarities among countries within the same industry (like in the case of similar export structures) as well as complementing different export structures through a market division of labour.

Conclusions

The dynamics of the CEECs' specialization and their convergence toward the EU export structure show that the process of re-shaping their pattern of trade has been long and profound, and it is still continuing. Along with this general result, the analysis undertaken in this work reveals different indications on the speed and the degree of similarity in trade patterns using different indices, rising a methodological issue on how to measure similarity. If similarity in trade structure should be a criterion for the formation of an integrated area, or

---

[20] The number of iterations varies in accordance to the significance of the test: 1,000 for $\alpha = 0.05$, 5,000 for $\alpha = 0.01$, 10,000 for greater precision (Legendre and Legendre 1998). Moreover, the Mantel's test is based on linear correlation and nonlinear relationships between variables may be degraded or lost. The test of time dependence is averaged over all time periods and so the test cannot discover changes in the pattern of correlation at different point in time.

an indicator of the adjustments expected, how to measure similarity and convergence is a point that needs to be tackled. Our contribution shows that when specialization changes are driven by sectors characterized by large export shares the use of a single aggregate index can be problematic. In particular, in this case the traditional correlation analysis can lead to misleading conclusions, and the Bray-Curtis metric is a better indicator.

Another result of the empirical analysis is that the evolution of different candidates is dissimilar, confirming that it is impossible to generalize the effects of trade integration on trade patterns. While we have a converging behaviour for Poland and Hungary (until 1995), moving away from the initial specialization toward the EU, Romania started to converge toward the EU only in the last few years and to a very small extent, and Bulgaria displays a diverging trend. It seems therefore that two different tendencies emerge, creating a ''convergence club'' and a group of countries that so far are not showing a clear and definitive sign of convergence towards the EU trade structure.

The evidence reported in the paper shows that CEECs total exports toward the EU are linked to other forms of integration, such as fragmentation of production. Processing trade can foster both convergence or divergence in trade structures, according to the characteristics of the sectors involved, and whether these are shrinking in the EU and being moved to other locations or expanding.

Finally, even if the heterogeneity among the CEECs has been already emphasized in many contributions, it is interesting that our comparison, without making any assumption on the countries' structural characteristics, indicates the countries displaying less convergence are also the countries that were found not ready for accession, using quite different criteria. This result gives support to the view of the evolution of trade patterns being in line with the evolution of other economic indicators.

Appendix

The Appendix contains three different sections. The first one contains the description of the sectors included in the analysis. The second one contains a detailed report of the time-trend regressions described in Fig. 1. The third one analytically replicates the dynamics of the EU-similarity for the Hungarian case, in order to identify the cause of different prediction rising from the use of the correlation index or the Bray-Curtis distance metric.

Appendix 1: data sources and sectors

The source of all the data presented in the tables and in the analysis of this paper is the Eurostat database Comext "Intra-EU and extra-EU trade", reporting annual trade data classified according to the Combined Nomenclature of the European Communities. The abbreviated definition of the 97 two-digit sectors of the Combined Nomenclature is reported in Table 3.

Appendix 2: time trend regressions

In this Appendix, we report the values of the CEECs exports towards the EU for 1989 and 2001 (Table 4). In Fig. 1, those values were normalized so that the values for 1992 equal 1.

In Tables 5 and 6 we report the regression statistics for the time trends pictured in Fig. 1.

Table 3 Sectors

Products			
Animals	Raw minerals	Silk	Nickel
Meat	Ores	Wool	Aluminium
Fish	Fuels	Cotton	Lead
Dairies	Inorganic chem.	Textile fibres	Zinc
Other animal prods.	Organic chem.	Filaments	Tin
Plants	Pharmaceuticals	Staple fibres	Other metals
Vegetables	Fertilizers	Special yarns	Cutlery and tools
Fruit	Dyes	Carpets	Other metal articles
Coffee and spices	Cosmetics	Tapestries	Machinery
Cereals	Soaps	Coated fabrics	Electrical machin.
Flours	Glues	Knitted fabrics	Railway
Seeds	Explosives	Knitted apparel	Autovehicles
Resins	Photog. Products	Apparel	Aircraft
Other vegetal prods.	Other chem.	Other textiles	Ships
Fats and oils	Plastics	Footwear	Precision tools
Meat preparations	Rubber	Hats	Clocks
Sugar	Leather	Umbrellas	Musical articles
Cocoa	Leather goods	Feather articles	Arms
Cereal preparations	Furs	Cement	Furniture
Veget. preparations	Wood	Ceramics	Toys
Other edibles	Cork	Glass	Other manuf.
Beverages	Wickerwork	Jewellery	Art pieces
Resid. food ind.	Cellulose	Iron	Others
Tobacco	Paper	Iron articles	
	Printing	Copper	

Table 4 Value of CEECs' exports to the EU (million euro)

	1989	1992	2001
Poland			
Total exports	3863.41	7080.60	26623.57
Processing trade	572.67	1279.34	1121.73
Final exports	3290.74	5801.26	25501.84
Hungary			
Total exports	2588.28	3987.85	24825.31
Processing trade	562.38	858.75	1080.37
Final exports	2025.90	3129.10	23744.94
Romania			
Total exports	2547.59	1403.86	9376.50
Processing trade	474.96	407.80	1329.68
Final exports	2072.63	996.06	8046.82
Bulgaria			
Total exports	530.43	905.38	3506.32
Processing trade	65.26	111.39	482.68
Final exports	465.18	793.99	3023.65

Table 5 Total Exports regressions on a time trend

	Estimate	SE	t Value	Pr $(> |t|)$	Adjusted-R^2
Poland					
Time trend	0.2489	0.0204	12.21	0.0000	0.925
Hungary					
Time trend	0.4607	0.0482	9.57	0.0000	0.883
Romania					
Time trend	0.4189	0.0596	7.03	0.0000	0.801
Bulgaria					
Time trend	0.2612	0.0189	13.81	0.0000	0.940

Table 6 Final Exports regressions on a time trend

	Estimate	<u>SE</u>	t Value	Pr $(> |t|)$	Adjusted-R^2
Poland					
Time trend	0.2412	0.0241	9.99	0.0000	0.891
Hungary					
Time trend	0.4454	0.0502	8.87	0.0000	0.866
Romania					
Time trend	0.3468	0.0598	5.80	0.0001	0.731
Bulgaria					
Time trend	0.2218	0.0182	12.18	0.0000	0.924

Appendix 3: r_{xy} vs. d_{xy}

Let's mimic the characteristics of the sectoral distribution in Hungary and in the EU cases assuming that, existing n different sectors, $i \in [1, n]$, one of these sectors—machinery—becomes progressively relevant in the case of Hungary

and remains stable in the case of the EU. We call x_j the Hungarian export share of that sector, and y_j the export share of the same sector in the European case, so that $x \equiv [x_1, \ldots, x_j, \ldots, x_n]$ and $y \equiv [y_1, \ldots, y_j, \ldots, y_n]$.

Since the data under scrutiny are export shares, then

$$\sum_i x_i \equiv \sum_i y_i \equiv 1 \tag{3}$$

and

$$\frac{\sum_i x_i}{n} \equiv \frac{\sum_i y_i}{n} \equiv \frac{1}{n}$$

The distribution is therefore characterized by a *constant* mean, regardless the changes in sectoral shares.

Let's focus the analysis on the changing sector x_j alone, shadowing the dynamic of the other n–1 sectors, so that the changes in the sectoral distribution of the x_i only depend on the variations of x_j. In the case of the EU, the sectoral distribution remains unchanged. Imposing symmetry on the n–1 residual sectors,[21] the linear correlation index expressed in Eq. 1 can be written as follows

$$r_{xy} = \frac{\sigma_{xy}}{\sigma_x \sigma_y} = \frac{\left(x_j - \frac{1}{n}\right)\left(y_j - \frac{1}{n}\right) + (n-1)\left(\frac{1-x_j}{n-1} - \frac{1}{n}\right)\left(\frac{1-y_j}{n-1} - \frac{1}{n}\right)}{\sigma_x \sigma_y} \tag{4}$$

where

$$\sigma_x = \sqrt{\left(x_j - \frac{1}{n}\right)^2 + (n-1)\left(\frac{1-x_j}{n-1} - \frac{1}{n}\right)^2}$$

and

$$\sigma_y = \sqrt{\left(y_j - \frac{1}{n}\right)^2 + (n-1)\left(\frac{1-y_j}{n-1} - \frac{1}{n}\right)^2}.$$

The sign of r_{xy} depends on x_j according to the following rule:

$$r_{xy} \begin{cases} <0 & \text{if} \quad x_j < \frac{1}{n} \\ =0 & \text{if} \quad x_j = \frac{1}{n} \\ >0 & \text{if} \quad x_j > \frac{1}{n} \end{cases}$$

and the sign of the partial derivative of r_{xy} w.r.t. x_j is

---

[21] Imposing a symmetry among the residual sectors is not a too strong and irrealistic assumption given the characteristics of the CEECs trade structure.

$$\frac{\partial r_{xy}}{\partial x_j} = \frac{\left(y_j - \frac{1-y_j}{n-1}\right)}{\sigma_x \sigma_y} - \frac{r_{xy}}{\sigma_x} \, \sigma_x' \begin{cases} <0 & \text{if} \quad y_j < \frac{1+(1-n)(r_{xy}\sigma_y\sigma_x')}{n} \\ >0 & \text{if} \quad y_j > \frac{1+(1-n)(r_{xy}\sigma_y\sigma_x')}{n} \end{cases}$$

where σ_x' is the partial derivative of σ_x w.r.t. x_j.

In the present symmetric case, since the dynamic of the n–1 residual sectors is perfectly collinear, r_{xy} will always take the values –1 or +1. In general, when n is sufficiently large and x_j is relevant as well, r_{xy} is positive and increases (decreases) as x_j becomes larger depending on y_j being sufficiently large (small).

In fact, the values in the Hungarian EU-similarity were $n = 97$, $y_j = 0.15$ and x_j was growing from a 10% to a 30% value between 1989 and 2001. It is now clear why r_{xy} was steadily growing during the period.

On the other hand, the Bray-Curtis metric expressed in Eq. 2 can be rewritten as

$$d_{xy}^{bc} = \frac{1}{2}\left(|y_j - x_j| + |x_j - y_j|\right). \tag{5}$$

given our assumptions on x_j and y_j and taking into account Eq. 3.

The sign of d_{xy}^{bc} is always positive while the sign of the partial derivative of d_{xy}^{bc} w.r.t. x_j is

$$\frac{\partial d_{xy}^{bc}}{\partial x_j} = -\frac{1}{2}\frac{|y_j - x_j|}{y_j - x_j} + \frac{1}{2}\frac{|x_j - y_j|}{x_j - y_j} \begin{cases} <0 & \text{if} \quad x_j < y_j \\ \text{undefined} & \text{if} \quad x_j = y_j \\ >0 & \text{if} \quad x_j > y_j \end{cases}$$

The shape of d_{xy}^{bc} only depends on the value of y_j and it decreases as x_j tends to y_j from the left, it has a kink when $x_j = y_j$, and increases for values of $x_j > y_j$.

This explains why in the Hungarian EU-similarity the distance metric was decreasing until when x_j reached the same value of y_j and suddenly it changed its slope. r_{xy} and d_{xy}^{bc} go in the same direction only for values of $x_j < y_j$, the concordance is broken when x_j becames greater than y_j.

In the choice between the correlation index and the Bray-Curtis metric, two general aspects run against the former. On the one hand, r_{xy} is heavily dependent on the mean and the standard deviation of the distribution of x_i and y_i that in case of pronounced skewness are distorted estimates of the location and the spread of the distribution. On the other hand, the mean value is fixed regardless of changes in the sectoral composition of export shares and it is sensitive to the number of sectors considered in the data aggregation.

The d_{xy}^{bc} semi-metric has instead the advantage of not increasing in n, of being invariant to proportional sub-classifications of the n sectors considered (Sun and Ng 2000), it is not subject to the *double-zeros paradox* (Legendre and Legendre 1998), it lessen the effect of the largest differences since difference in high sectoral export shares contribute the same as difference between small sectoral export shares, and is appropriate in presence of skewed distributions.

Finally, since d_{xy}^{bc} catches changes in the sign of $x_j−y_j$ while r_{xy} reacts minimally to those changes, the former has to be preferred to the latter, when the sign of $x_j−y_j$ is of interest. In other cases the two are monotone. d_{xy}^{bc} should be therefore preferred to r_{xy} in general.

References

Brenton P, Manchin M (2003) Making EU trade agreements work: the role of rules of origin. World Econ 26(5):755–769

Chiarlone S (2002) Country specialization and trade overlap: whom are the central-eastern european countries competing with? In: Baldone S, Sdogati F, Tajoli L (eds) EU enlargement to the CEECs: trade competition, delocalization of production and effects on the economies of the Union. Franco Angeli Editore, Milano

Clark T, van Wincoop E (2000) Borders and business cycles. J Intl Econ 55:59–85

De Arcangelis G, De Benedictis L, Tajoli L (2005) Una analisi settoriale comparata della frammentazione internazionale della produzione verso la Romania. L'Italia nell'Economia Internazionale—Rapporto ICE 2004-2005 290–299

Facchini G, Segnana ML (2003) Growth at the EU periphery: the next enlargment. Quart Rev Econ Finance 43:827–862

Finger JM, Kreinin ME (1979) A measure of 'export similarity' and its possible uses. Econ J 89(356):905–912

Forslid R, Haaland JI, Knarvik KHM (2002) A U-shaped Europe? A simulation study of industrial location. J Intl Econ 75(2):273–297

Halpern L (1995) Comparative advantage and likely trade pattern of the CEECs. In: Faini R, Portes R (eds), European Union Trade with Eastern Europe. CEPR, London, pp 61–85

Hoekman B, Djankov S (1997) Determinants of the export structure of countries in Central and Eastern Europe. World Bank Econ Rev 11(3):471–487

Imbs J (2001) Co-Fluctuations, CEPR Discussion Paper no. 2267

Kaminski B, Wang Z, Winters A (1996) Explaining trade reorientation in transition economies. Econ Policy 23:421–442

Krugman P (1981) Intraindustry specialization and the gains from trade. J Polit Econ 89:5

Krugman P (1991) Geography and trade. The MIT Press, New York

Landesmann M (2002) Trade integration and changing trade structures of transition economies. In: Tumpel-Gugerell G (ed) Completing transition: the main challenges. Springer Pub, pp 222–247

Landesmann M, Stehrer (2002) Evolving competitiveness of CEECs in an Enlarged Europe. Rivista Polit Econ 92(1–2):23–87

Legendre P, Legendre L (1998) Numerical Ecology, 2nd edn. Elsevier, Amsterdam, The Netherlands

Menon J, Dixon P (1997) Intraindustry vs interindustry trade: relevance for adjustment costs. Weltwirtshaftliches Archiv 133(1):164–169

Redding S (2002) Specialization dynamics. J Intl Econ 58(2):299–334

Sun GZ, Ng YK (2000) The measurement of structural differences between economies: an axiomatic characterization. Econ Theory 16:313–321

Svejnar J (2002) Transition economies: performance and challenges. J Econ Perspect 16(1):3–28